Falcon Test User Interface:

The Novint Falcon Test application user-interface is broken into six main sections: USB Communications, Front LEDs, Buttons, Homing, Position Sensors and Motors (see *figure 1*).

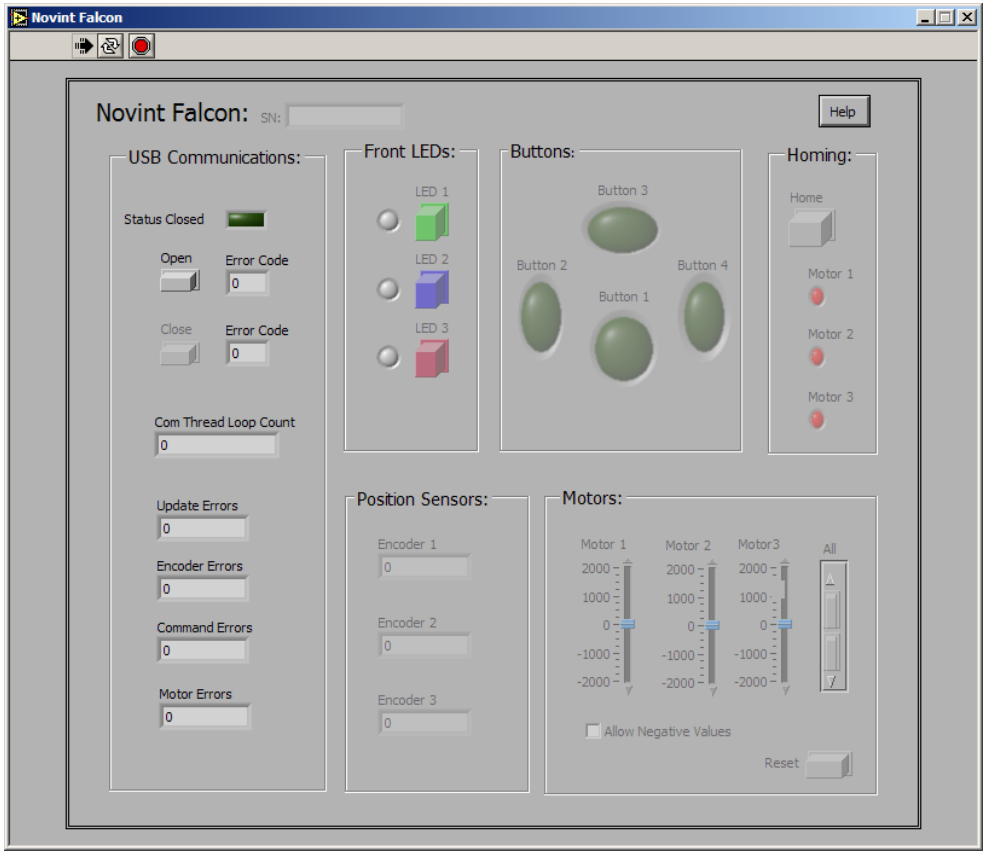


Figure 1

USB Communications

This grouping of controls and indicators is responsible for opening and closing USB communications with Falcon device, tracking communication status with Falcon device, and logging errors that occur.

- **Status** -- the *Status* LED indicator shows the current state of communications with Falcon Device. The *Status* LED indicator shows 3 communication states: closed, open and error. The *Status* LED indicator is: dark green when communications with Falcon Device are closed, bright green when communications are opened and functioning normally, and flashes red and yellow when: communications with Falcon device could not be opened, communication with Falcon device is lost or too many update errors occur (see *Update Errors* below for details).
- **Open** – depressing the <*Open*> button opens communications with Falcon device. If an error occurs while opening communications with Falcon device an error code will be logged in the *Error Code* indicator, the *Status* LED indicator will begin to flash yellow and red and an audible buzzing alert will be heard.
- **Close** – depressing the <*Close*> button closes communications with Falcon device. If an error occurs while closing communications with Falcon device an error code will be logged in the *Error Code* indicator.
- **Com Thread Loop Count** – the *Com Thread Loop Count* specifies the number of communication loops that have occurred since communications with Falcon device were opened.
- **Update Errors** – the *Update Errors* indicator logs the number of update errors that have occurred since communications with Falcon device were opened. Update errors are acceptable unless 10 or more update errors occur during the last 100 communication thread loops. If update errors reach an unacceptable level the *Status* LED indicator will begin to flash yellow and red and an audible buzzing alert will be heard.
- **Encoder Errors** – the *Encoder Errors* indicator logs the number of encoder errors that have occurred since communications with Falcon device were opened.
- **Command Errors** – the *Command Errors* indicator logs the number of command errors that have occurred since communications with Falcon device were opened.
- **Motor Errors** – the *Motor Errors* indicator logs the number motor errors that have occurred since communications with Falcon device were opened.

LEDs

This grouping of button controls toggle the state of the Corresponding LED on the Falcon Device (see step 8 for details).

Buttons

This grouping of LED indicators turn bright green when the corresponding button on the Falcon's Spherical End Effector is depressed.

Homing

The control and indicators in this group are responsible for sending the motor homing command and displaying the current homing state of Motor 1, Motor 2 and Motor 3 of the Falcon device.

- **Home** – the <*Home*> button sends the enable homing command for all Falcon device motors when it is depressed.
- **Motor 1** – the *Motor 1* LED is dark green when Motor 1 is not homed and bright green when Motor 1 is homed.
- **Motor 2** -- the *Motor 2* LED is dark green when Motor 2 is not homed and bright green when Motor 2 is homed.
- **Motor 3** -- the *Motor 3* LED is dark green when Motor 3 is not homed and bright green when Motor 3 is homed.

Position Sensors

This grouping of indicators displays the current encoder values of Falcon device's Encoder 1, Encoder 2 and Encoder 3.

Motors

This grouping of controls is responsible for setting torque value for each individual motor and as a group of the Falcon device.

- **Motor 1** – the <*Motor 1*> slider control sets the torque value for Motor 1 of the Falcon device between 2000 and -2000.
- **Motor 2** – the <*Motor 2*> slider control sets the torque value for Motor 2 of the Falcon device between 2000 and -2000.
- **Motor 3** – the <*Motor 3*> slider control sets the torque value for Motor 3 of the Falcon device between 2000 and -2000.
- **All** – the <*All*> composite control increments or decrements Motor 1, Motor 2 and Motor 2 torques of the Falcon device by 500 simultaneously.
- **Reset** – the <*Reset*> button simultaneously sets torque to zero for Motor 1, Motor 2 and Motor 3.
- **Allow Negative Values** – the < *Allow Negative Values*> button enables/disables feature allowing all torques to be simultaneously decremented.

In Addition, there is a device SN indicator and a **Help** button, which when pressed displays instructions and shortcut keys for the Falcon Test application.

Falcon Test Procedure:

Required Equipment:

1. Falcon device with Spherical End Effector
2. Falcon Power Cord
3. USB 2.0 cable
4. Test computer with:
   - Falcon Driver pre-installed
   - LabView Falcon Test application pre-installed
   - Accessible USB 2.0 cable port

Falcon Testing Positions to be familiar with:

Retracted Arm Position

Intermediate Arm Position

Extended Arm Position

Falcon Test Procedure:

1. **Setup.**

   Instructions:

   - Place device in location with access to power outlet and test computer and make sure computer volume is set to an audible level.

Note: Neither the Falcon Power Cord or the USB 2.0 Cable should be connected to the Falcon device at this point. It is ok to have USB 2.0 cable connected to test computer and have the Falcon Power Cord connect to a power outlet at this point.

- Make sure the Spherical End Effector is properly installed (i.e., locked into end effector base receptacle).

Procedures:

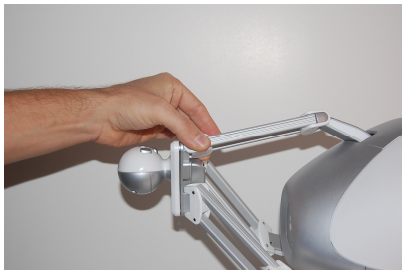
	√	**Prepare Falcon and computer for testing.**			
	___	Falcon is in test location with access to power cord and USB 2.0 cable			
	___	USB 2.0 cable is NOT connected to Falcon			
	___	Falcon Power Cord is NOT connected to Falcon			
	___	Volume on test computer is set to an audible level			
	___	Spherical End Effector is properly installed			

2. **Test movement of Falcon Arms.**

Instructions:

- Move arms of the Falcon device while holding the Spherical End Effector (see picture below). Movement should include the full range of motion of device. Tester should feel smoothness through the full range of motion of Falcon arms -- no clicking or binding should be heard or felt.

- Move each arm separately by grabbing each arm by the white hinges … see figures below. Tester should feel smoothness through the full range of motion of Falcon arms -- no clicking or binding should be heard or felt.



Procedures:

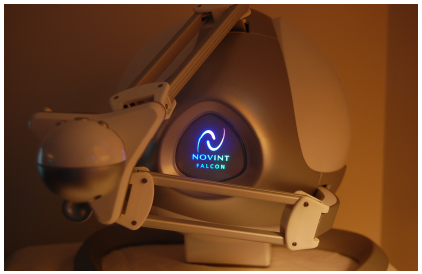
Yes	No	**Manually test Falcon mechanism for smoothness. Success means that mechanical arm assembly was successful.**	**Pass**	**Fail**	**Action on Fail**
___	___	Movement of arms while holding Spherical End Effector feels smooth?	Smooth movement.	Difficult to move, excessive bumps or noise.	Stop test. Examine mechanical assembly.
___	___	Top Arm feels smooth when moved?	Smooth movement.	Difficult to move, excessive bumps or noise.	Stop test. Examine mechanical assembly.
___	___	Left Arm feels smooth when moved?	Smooth movement.	Difficult to move, excessive bumps or	Stop test. Examine mechanical assembly.

				noise.	
___	___	Right Arm feels smooth when moved?	Smooth movement.	Difficult to move, excessive bumps or noise.	Stop test. Examine mechanical assembly.

3. **USB 2.0 Connection.**

Instructions:

- Connect USB 2.0 cable to the computer's USB 2.0 port (if not already connected) and then to Falcon USB 2.0 port on the back of the Falcon device (see figure below).
- Listen for the standard audible double beep from computer acknowledging the Falcon Device has been properly plugged in.
- In Addition, if a proper USB connection has been made between the Falcon device and the computer, the tester will feel some friction and damping if Falcon arms are moved and all 3 LEDs on the Novint Falcon Logo Badge will have turned on (see figure below).



Procedures:

		Connect Falcon to USB 2.0 on computer.	Success		

			means that the computer recognizes the Falcon and that tests can continue.		
	√				
___	___	Connect USB 2.0 cable between Falcon and computer.			
Yes	**No**		**Pass**	**Fail**	**Action on Failure**
___	___	Audible double beep was heard when USB 2.0 cable was connected to the Falcon?	Sounds heard.	Sounds not heard.	Continue test. Suspect that Falcon Main PCBA is bad or USB communication is not established.
___	___	Some friction and dampening is now felt when Falcon arms are moved?	Movement smooth but more difficult than in Test 2.	Movement not more difficult than in Test 2.	Continue test. Suspect that Falcon Main PCBA is bad or USB port on Falcon is not receiving appropriate current.
___	___	All three (3) LEDs are seen on Novint Falcon Logo Badge?	All three (3) LEDs are turned on and visible.	Less than three (3) LEDs are turned on and visible.	Stop test. Unplug USB 2.0 connection, wait 5 seconds and plug the USB 2.0 connection in again. If test fails again and the golden Falcon passes this same test, repair or replace Main PCBA.

					If golden Falcon also fails, check USB cable to make sure it is connected. If still fails, reboot computer and try again.

4. Power Connection.

Instructions:

- Plug the Falcon Power Cord into power outlet (if not already plugged in) and then into Falcon power jack. Note: at this point Falcon device LED 1 (Green), LED 2 (Blue), & LED 3 (Red) behind Novint Falcon Logo Badge should be on (see figure below).

Procedures:

		Connect Falcon power supply so that further tests can be done.	Success indicates that Falcon power supply is good.		
	√				
	___	Connect Falcon power supply to A/C mains and to the Falcon.			

Yes	No		Pass	Fail	Action on Failure
___	___	LEDs on Falcon Logo Badge get brighter?	LEDs get brighter on connecting power supply to Falcon.	LEDs do not get brighter on connecting power supply to Falcon.	Check power supply voltage (30V). If no voltage make sure power supply is connected to A/C mains. If power supply voltage is below 29V, fail power supply. Get new power supply and continue tests.

5. Novint Falcon Test application started with no problems.

Instructions:

- Start Falcon Test application.

Procedures:

		Start FalconTest program.	Success indicates that the testing program is properly installed on the computer and the tests can continue.		
	√				

	___	Start FalconTest.exe application.			
Yes	**No**		**Pass**	**Fail**	**Action on Failure**
___	___	Novint Falcon Test application started with no problems?	Falcon Test application comes up and graphical user interface is seen.	Falcon Test application graphical user interface is not seen.	Suspect improper Falcon Test installation. Reboot the computer and try again. If still failing, discontinue tests until Falcon Test program is properly installed.

6. Open USB Communication Link.

Instructions:

- Open USB communication link with device by clicking on the <Open> button or pressing the <O> shortcut key.

  Note:
  - You should hear and audible beep acknowledging the <Open> button has been pressed
  - LED 1, LED 2 and LED 3 on Falcon Device should all turn off
  - Falcon Test application *Status* indicator should change to an active bright green state
  - *Com Thread Loop Count* indicator will now be incremented once for every communication thread loop
  - Update errors, encoder errors, command errors and motor errors will also begin to be logged in Falcon Test application.
  - Update errors are acceptable, except if 10 or more update errors occur during the last 100 Com Thread Loops. If update errors reach an unacceptable level the *Status* indicator will begin to flash yellow and red and an audible buzzing alert will be heard.
  - Friction and damping in Falcon arm movement introduced when USB connection was made should now be gone.

Procedures:

	√	**Open USB Communication Link.**			
	___	Select Open button in Communications section of Falcon Test application			
Yes	**No**		**Pass**	**Fail**	**Action on Failure**
___	___	LED 1, LED 2 and LED 3 all turned off?	All three Novint Logo LEDs turn off.	One or more Novint Logo LEDs do not turn off.	Suspect that USB communication is not established. Continue test.
___	___	Falcon Test application Status indicator in Communication section of Falcon Test application turned green?	Status indicator turns green and audible beep is heard. Com Thread Loop Count indicator value should also be increasing quickly.	Status indicator above Open remains off or is yellow or red in color.	Note Error Code (if any). If status indicator remains off, suspect that USB communication controller on Main PCBA has not been programmed or that it has failed. Exit the Falcon Test application, remove power cable from Falcon, remove USB cable from Falcon, connect USB cable to Falcon, connect power cable to Falcon and re-start test program. On continued failure,

					suspect major failure of Falcon Main PCBA. Try golden Falcon and if that works, fail the Falcon being tested. If golden Falcon also fails, re-boot PC and try again. Note that the failed Falcon should be tested with MProg. Run Device->Scan in MProg. If unit not found, major failure of Main PCBA. If unit found but not programmed, program the USB Communication Controller on the Main PCBA.
		Error Code (if any): _____			
Yes	**No**		**Pass**	**Fail**	**Action on Failure**
___	___	Friction and damping in Falcon arm movement introduced when USB connection was made is now gone?	Smooth movement as felt in Test 2.	Movement feels the same as in Test 3.	Suspect main PCBA failure or that motors are not properly connected. Continue tests.

7. Novint Logo Badge LEDs

Instructions:

- Click on <LED 1> button to toggle the state of Green LED on the Falcon device
- Click on <LED 2> button to toggle the state of Blue LED on the Falcon device
- Click on <LED 3> button to toggle the state of Red LED on the Falcon device

Note: if LEDs have been properly installed in the correct order, LED button number pushed should correspond to button color.

Procedures:

		Tests function and correct placement of Novint Logo Badge LEDs.	Continues to verify that USB communication between the computer and the Falcon is working and that the Main PCBA digital signal processor and USB Communication Controller are working.		
Yes	**No**		**Pass**	**Fail**	**Action on Failure**
___	___	Depressing LED 1 button in the LEDs section of the Falcon Test application turns on the green LED on the Falcon device?	A green LED on the front of the Falcon	No LED or an LED of another	Note failure condition and at the end of Test 7, discontinue testing

			lights up.	color lights up.	and repair Main PCBA so that a working LED or LED of appropriate color is installed.
		If No, check one: _____ No LED _____ Blue LED _____ Red LED			
___	____	Depressing LED 2 button in the LEDs section of the FalconTest application turns on the blue LED on the Falcon device?	A blue LED on the front of the Falcon lights up.	No LED or an LED of another color lights up.	Note failure condition and at the end of Test 7, discontinue testing and repair Main PCBA so that a working LED or LED of appropriate color is installed.
		If No, check one: _____ No LED _____ Green LED _____ Red LED			
___	___	Depressing LED 3 button in the LEDs section of the FalconTest application turns on the red LED on the Falcon device?	A red LED on the front of the Falcon lights up.	No LED or an LED of another color lights up.	Note failure condition and at the end of Test 7, discontinue testing and repair Main PCBA so that a working LED or LED of appropriate color is installed.
		If No, check one: _____ No LED _____ Green LED _____ Blue LED			

8. Buttons on Spherical End Effector.

Instructions:

- Depress <Button 1> on Spherical End Effector … *Button 1* status indicator should now be bright green in the Falcon Test application.
- Depress <Button 2> on Spherical End Effector … *Button 2* status indicator should now be bright green in the Falcon Test application.
- Depress <Button 3> on Spherical End Effector … *Button 3* status indicator should now be bright green in the Falcon Test application.
- Depress <Button 4> on Spherical End Effector … *Button 4* status indicator should now be bright green in the Falcon Test application.

Note: button depressed on Spherical End Effector should correspond to button status indicator position in the Falcon Test application.

Procedures:

		Test function of Spherical End Effector.	Failure indicates bad End Effector, incorrect wiring to the end effector interface or failure of end effector communication circuitry on the Main PCBA.		
Yes	**No**		**Pass**	**Fail**	**Action on Failure**
___	___	Depressing Button 1 on Spherical End Effector turned on Button 1 status LED indicator?	The button indicator in the	The button indicator in	Suspect that the end effector or the Falcon

			Buttons section of the Falcon Test program corresponding to this button lights up brightly in green when the Spherical End Effector button is depressed.	the Buttons section of the Falcon Test program corresponding to this button does NOT light up brightly in green when the Spherical End Effector button is depressed.	Base unit is bad. Remove end effector and re-install it. Try test again. If still fails, try golden Spherical End Effector. If Golden end effector passes, then repair/replace end effector that was under test. If golden Spherical End Effector fails, then Falcon Base unit is bad. Test wiring in Falcon Base unit and repair/replace as appropriate. If wiring passes, then Main PCBA has failed. Repair/replace Main PCBA.
___	___	Depressing Button 2 on Spherical End Effector turned on Button 2 status LED indicator?	The button indicator in the Buttons section of the Falcon Test program corresponding to this button lights up brightly in	The button indicator in the Buttons section of the Falcon Test program corresponding to this button does NOT	Suspect that the end effector or the Falcon Base unit is bad. Remove end effector and re-install it. Try test again. If still fails, try golden Spherical End Effector. If Golden

			green when the Spherical End Effector button is depressed.	light up brightly in green when the Spherical End Effector button is depressed.	end effector passes, then repair/replace end effector that was under test. If golden Spherical End Effector fails, then Falcon Base unit is bad. Test wiring in Falcon Base unit and repair/replace as appropriate. If wiring passes, then Main PCBA has failed. Repair/replace Main PCBA.
___	___	Depressing Button 3 on Spherical End Effector turned on Button 3 status LED indicator?	The button indicator in the Buttons section of the Falcon Test program corresponding to this button lights up brightly in green when the Spherical End Effector button is depressed.	The button indicator in the Buttons section of the Falcon Test program corresponding to this button does NOT light up brightly in green when the Spherical End Effector button is depressed.	Suspect that the end effector or the Falcon Base unit is bad. Remove end effector and re-install it. Try test again. If still fails, try golden Spherical End Effector. If Golden end effector passes, then repair/replace end effector that was under test. If golden Spherical End Effector fails, then Falcon Base unit is

					bad. Test wiring in Falcon Base unit and repair/replace as appropriate. If wiring passes, then Main PCBA has failed. Repair/replace Main PCBA.
___	___	Depressing Button 4 on Spherical End Effector turned on Button 4 status LED indicator?	The button indicator in the Buttons section of the Falcon Test program corresponding to this button lights up brightly in green when the Spherical End Effector button is depressed.	The button indicator in the Buttons section of the Falcon Test program corresponding to this button does NOT light up brightly in green when the Spherical End Effector button is depressed.	Suspect that the end effector or the Falcon Base unit is bad. Remove end effector and re-install it. Try test again. If still fails, try golden Spherical End Effector. If Golden end effector passes, then repair/replace end effector that was under test. If golden Spherical End Effector fails, then Falcon Base unit is bad. Test wiring in Falcon Base unit and repair/replace as appropriate. If wiring passes, then Main PCBA has failed. Repair/replace Main

					PCBA.

9. Homing Position Encoders.

Instructions:

- Grab Spherical End Effector and push arms into the Retracted Arm Position
- Click on the <*Home*> button or press the <H> shortcut key.
- Pull Spherical End Effector out horizontally until Extended Arm Position is reached
- Push arms into the Retracted Arm Position again – Motor 1, Motor 2 and Motor 3 homing status LED indicators in Falcon Test application should have turned from red to bright green in color

Procedures:

		Tests function of the homing/calibration mechanisms and circuitry of the Falcon.	Failure indicates a mechanical issue in the G-Link mechanism, an electrical issue in one of the photo-interrupter PCBAs or an issue with encoder circuitry on the		

			Main PCBA.		
	√				
	__	Move Falcon arms into Retracted Arm Position			
	__	Select the Home button in the Homing section of the Falcon Test application			
	__	Move Falcon arms into the Extended Arm Position			
	__	Move Falcon arms into Retracted Arm Position			
Yes	**No**		**Pass**	**Fail**	**Action on Failure**
__	___	Motor 1 homing status indicator in the Homing section of the Falcon Test application turned green	The status indicator next to the Motor 1 homing status indicator turns green.	The status indicator next to the Motor 1 homing status indicator remains red.	Move the arms again to Retracted Arm Position, then to Extended Arm Position and then back to Retracted Arm Position. If still failing, stop testing. The Falcon back cover should be removed and the photo-interrupter PCBA outputs should be checked. If any of these PCBAs fail, replace them. In addition, the flags on the G-Links should be checked to make sure that they are properly installed and passing through the

					photo-interrupter boards. If a flag is missing or mis-installed, install them correctly. If the photo-interrupter PCBAs check-out and the flags look good, suspect the photo-interrupter circuitry on the Main PCBA. Repair/exchange the Main PCBA.
___	___	Motor 2 homing status indicator in the Homing section of the Falcon Test application turned green	The status indicator next to the Motor 2 homing status indicator turns green.	The status indicator next to the Motor 2 homing status indicator remains red.	Move the arms again to Retracted Arm Position, then to Extended Arm Position and then back to Retracted Arm Position. If still failing, stop testing. The Falcon back cover should be removed and the photo-interrupter PCBA outputs should be checked. If any of these PCBAs fail, replace them. In addition, the flags on

					the G-Links should be checked to make sure that they are properly installed and passing through the photo-interrupter boards. If a flag is missing or mis-installed, install them correctly. If the photo-interrupter PCBAs check-out and the flags look good, suspect the photo-interrupter circuitry on the Main PCBA. Repair/exchange the Main PCBA.
___	___	Motor 3 homing status indicator in the Homing section of the Falcon Test application turned green	The status indicator next to the Motor 3 homing status indicator turns green.	The status indicator next to the Motor 3 homing status indicator remains red.	Move the arms again to Retracted Arm Position, then to Extended Arm Position and then back to Retracted Arm Position. If still failing, stop testing. The Falcon back cover should be removed and the photo-interrupter

					PCBA outputs should be checked. If any of these PCBAs fail, replace them. In addition, the flags on the G-Links should be checked to make sure that they are properly installed and passing through the photo-interrupter boards. If a flag is missing or mis-installed, install them correctly. If the photo-interrupter PCBAs check-out and the flags look good, suspect the photo-interrupter circuitry on the Main PCBA. Repair/exchange the Main PCBA.

10. **Motor Torques.**

Instructions:

- Grab Spherical End Effector and push arms into Retracted Arm Position.

- Set motor torque on Motor 1, Motor 2 and Motor 3 to **1000** simultaneously by clicking on the increment <All> button or pressing the <Up Arrow> shortcut key twice. Note: if motors are wired correctly arms will pull toward Retracted Arm Position.
- Pull arms slowly into Intermediate Arm Position. Tester should feel all arms actively pulling back towards Retracted Arm Position.
- Slowly and gently allow arms to return to Retracted Arm Position.

Procedures:

		Tests function and appropriate wiring of Falcon motors.	Success indicates that motor drive circuitry is working, motors are correctly working and that the motors are correctly wired.		
	√				
	___	Move Falcon arms to the Retracted Arm Position			
	___	Set torques of all three motors to 1000 using the All control in the Motors section of the Falcon Test application.			
	___	Pull Spherical End Effector into Intermediate Arm Position.			
	___	Gently return Spherical End Effector into Retracted Arm Position.			
Yes	**No**		**Pass**	**Fail**	**Action on Failure**

___	___	All arms pull back toward the Retracted Arm Position when all motor torques are set to 1000?	All arms are actively pulled by the Falcon towards the Retracted Arm Position.	One or more of the motors do not pull towards the Retracted Arm Position when the Falcon is held in the Intermediate Arm Position.	Stop tests. Check wiring on failed motor(s). If wiring is correct, suspect either motor or Main PCBA motor drive circuitry.

11. Calibration Loss.

Instructions:

- Grab Spherical End Effector and push arms into Retracted Arm Position.
- Set motor torque on Motor 1, Motor 2 and Motor 3 to **1000** simultaneously by clicking on the increment <All> button or pressing the <Up Arrow> shortcut key twice.
- Take note of *Encoder 1, Encoder 2 and Encoder 3* indicator readings in the Retracted Arm Position. All encoder indicator displays should read between 1200 and 1600.
- Set motor torque on *Motor 1, Motor 2 and Motor 3* to 0 simultaneously by clicking on <Reset> button or pressing the <Space Bar> shortcut key.
- Quickly move Spherical End Effector into the Extended Arm Position and back to the Retracted Arm position three times. Tester should finish sequence holding the Spherical End Effector in the Retracted Arm Position.
- With Spherical End Effector still in Retracted Arm Position, set motor torque on Motor 1, Motor 2 and Motor 3 to **1000** simultaneously by clicking on the increment <All> button or pressing the <Up Arrow> shortcut key twice.

- Take note of *Encoder 1, Encoder 2 and Encoder 3* indicator readings in the Retracted Arm Position. Individual encoder readings should not vary significantly (+-100) from previous encoder readings noted above when all motors were set to 1000.
- With Spherical End Effector still in Retracted Arm Position, set motor torque on Motor 1, Motor 2 and Motor 3 to **2000** simultaneously by clicking on the increment <All> button or pressing the <Up Arrow> shortcut key twice.
- Take note of *Encoder 1, Encoder 2 and Encoder 3* indicator readings in the Retracted Arm Position after a 5 – 10 second observation period. Individual encoder readings should not vary significantly (+-5) during the 5 – 10 second observation period.

Procedures:

		Tests Falcon encoder/position calibration.	Success indicates that mechanical encoder wheels are correctly installed and that encoder emitter/detectors are the Main PCBA are working and correctly aligned.		
	√				
	___	Torques for all three motors set to 1000 and Falcon arms are in the Retracted Arm Position.			
		Encoder 1 indicator reads: _____			
		Encoder 2 indicator reads: _____			

		Encoder 3 indicator reads: _____			
Yes	**No**		**Pass**	**Fail**	**Action on Failure**
___	___	In Retracted Arm Position with Motor 1 torque set 1000, Encoder 1 indicator reads between 1200 and 1600?	Encoder indicator reads between 1200 and 1600 [note: values below 1400 are sub-optimal but pass]	Any value below 1200 or above 1600.	Stop testing. Check placement of G-Link flags. If OK, make sure that G-Link levers are seated. If OK, fail unit and analyze for out of tolerance mechanical components.
___	___	1000, Encoder 2 indicator reads between 1200 and 1600?	Encoder indicator reads between 1200 and 1600 [note: values below 1400 are sub-optimal but pass]	Any value below 1200 or above 1600.	Stop testing. Check placement of G-Link flags. If OK, make sure that G-Link levers are seated. If OK, fail unit and analyze for out of tolerance mechanical components.
___	___	1000, Encoder 2 indicator reads between 1200 and 1600?	Encoder indicator reads between 1200 and 1600 [note: values below 1400 are sub-optimal but pass]	Any value below 1200 or above 1600.	Stop testing. Check placement of G-Link flags. If OK, make sure that G-Link levers are seated. If OK, fail unit and analyze for out of tolerance mechanical components.
	√				

	___	Torques for all three motors set to 0 and Falcon arms are in the Retracted Arm Position.			
	___	Move arms in/out quickly 3 times between Retracted and Extended Arm Positions and return the Falcon arms to the Retracted Arm Position.			
	___	Torques for all three motors set to 1000 and Falcon arms are in the Retracted Arm Position.			
Yes	**No**		**Pass**	**Fail**	**Action on Failure**
___	___	In Retracted Arm Position with Motor 1 torque set 1000, Encoder 1 indicator reads: _____ and this value is +/-100 within Encoder 1 value prior to in/out movement of arms?	Encoder indicator is within +/-100 of first reading of this encoder.	Encoder indicator differs from first reading for this encoder by greater than +/- 100.	Stop testing. Failure indicates that the encoder emitter/detector pair on the Main PCBA are incorrectly installed. Open the back of the Falcon and inspect placement and orientation of emitter and detector. Modify as required. Test again. If fails, again, fail the unit and repair/exchange Main PCBA.
		In Retracted Arm Position with Motor 2 torque set 1000, Encoder 2 indicator reads: _____ and this value is +/-100 within Encoder 2 value prior to in/out movement of arms?	Encoder indicator is within +/-100 of first reading of this encoder.	Encoder indicator differs from first reading for this encoder by	Stop testing. Failure indicates that the encoder emitter/detector pair on the Main PCBA are incorrectly

				greater than +/- 100.	installed. Open the back of the Falcon and inspect placement and orientation of emitter and detector. Modify as required. Test again. If fails, again, fail the unit and repair/exchange Main PCBA.
		In Retracted Arm Position with Motor 3 torque set 1000, Encoder 3 indicator read: _____ and this value was +/-100 within Encoder 3 value prior to in/out movement of arms?	Encoder indicator is within +/-100 of first reading of this encoder.	Encoder indicator differs from first reading for this encoder by greater than +/- 100.	Stop testing. Failure indicates that the encoder emitter/detector pair on the Main PCBA are incorrectly installed. Open the back of the Falcon and inspect placement and orientation of emitter and detector. Modify as required. Test again. If fails, again, fail the unit and repair/exchange Main PCBA.
	√				
	___	Torques for all three motors set to 2000 and Falcon arms are in the Retracted Arm Position.			

Yes	No		Pass	Fail	Action on Failure
___	___	In Retracted Arm Position with Motor 1 torque set 2000, Encoder 1 indicator reads: _____ and remained stable within +-5 range during 10 second period?	Encoder value does not change more than +/- 5 over 10 second period.	Any change in encoder reading greater than +/-5 over 10 second period.	Stop the test. The motor capstan is slipping on the shaft or the encoder wheel is slipping relative to the capstan or motor shaft. Check mechanical construction of unit. Make sure that the set screw on the capstan is appropriately tightened and is engaging the flat part of the motor shaft.
___	___	In Retracted Arm Position with Motor 2 torque set 2000, Encoder 2 indicator reads: _____ and remained stable within +-5 range during 10 second period?	Encoder value does not change more than +/- 5 over 10 second period.	Any change in encoder reading greater than +/-5 over 10 second period.	Stop the test. The motor capstan is slipping on the shaft or the encoder wheel is slipping relative to the capstan or motor shaft. Check mechanical construction of unit. Make sure that the set screw on the capstan is appropriately tightened and is

					engaging the flat part of the motor shaft.
		In Retracted Arm Position with Motor 3 torque set 2000, Encoder 3 indicator reads: _____ and remained stable within +-5 range during 10 second period?	Encoder value does not change more than +/- 5 over 10 second period.	Any change in encoder reading greater than +/-5 over 10 second period.	Stop the test. The motor capstan is slipping on the shaft or the encoder wheel is slipping relative to the capstan or motor shaft. Check mechanical construction of unit. Make sure that the set screw on the capstan is appropriately tightened and is engaging the flat part of the motor shaft.

12. Safety/Kill Circuit.

Instructions:

- While still holding Spherical End Effector in Retracted Arm Position from previous step.
- Set motor torque on Motor 1, Motor 2 and Motor 3 to **1000** simultaneously by clicking on the decrement <All> button or pressing the <Down Arrow> shortcut key twice.
- Make sure all arms a pulling back towards Retracted Arm Position.
- Detach and remove Spherical End Effector from Falcon.

- Note if all arms stopped pulling back toward Retracted Arm Position when Spherical End Effector was detached and removed from Falcon.
- Re-attach Spherical End Effector to Falcon. All arms should now pull towards Retracted Arm Position again.

Procedures:

		Tests for proper operations of Falcon safety/kill circuitry in Falcon Main Unit and Spherical End Effector.	Success indicates Main PCBA kill circuitry is correct, wiring to end effector interface in the Main Unit is correct and that the Spherical End Effector is working.		
	√				
	___	Torques for all three motors set to 1000 and arms are in Retracted Arm Position.			
Yes	**No**		**Pass**	**Fail**	**Action on Failure**
___	___	All arms pull back toward Retracted Arm Position when all motor torques were set to 1000?			
	√				
	___	Remove Spherical End Effector from Falcon Main Unit.			
Yes	**No**		**Pass**	**Fail**	**Action on Failure**
___	___	All arms Stopped pulling back toward Retracted Arm Position after Spherical End Effector was removed	Motors do not pull the arms	Motors continue to	Try test again with a golden end effector.

		from Falcon Main Unit?	towards the Retracted Arm Position.	pull the arms towards the Retract Arm Position.	If golden end effector works, repair/replace the tested end effector. If golden end effector fails, check wiring in Falcon Main Unit to make sure that Kill signal is appropriately wired. If signal is appropriately wired, Main PCBA is bad and should be repaired/replaced.
	√				
	___	Re-attach Spherical End Effector from Falcon Main Unit.			
Yes	**No**		**Pass**	**Fail**	**Action on Failure**
___	___	All arms pull back toward Retracted Arm Position when Spherical End Effector was re-attached?	Motors now pull the arms towards the Retract Arm Position.	Motors do not pull the arms towards the Retracted Arm Position.	Try test again with a golden end effector. If golden end effector works, repair/replace the tested end effector. If golden end effector fails, check wiring in Falcon Main Unit to make sure that Kill signal is

					appropriately wired. If signal is appropriately wired, Main PCBA is bad and should be repaired/replaced.

13. Close USB Communication Link.

Instructions:

- Close USB communication link by clicking on <Close> button or pressing <C> shortcut key.
- An audible closing beep should be heard when the communication link is closed.
- Note any error code displayed.
- Close Falcon Test application.
- Note that Falcon Test application MUST be closed between testing different Falcons.

Procedures:

		Close USB Communication Link.			
	√				
	___	Hit Close button			
Yes	**No**		**Pass**	**Fail**	**Action on Failure**
___	___	Audible beep was heard when communications were closed and Open button in the Communications section of the Falcon Test application is available?	Open button is available and Close button is grayed out.	Open button is NOT available and Close button is still active.	Hit the Close button again. If it now works, OK. If not, close the FalconTest Program, hit Open and Close again. If

					OK then unit is fine. If cannot Open communications, close the FalconTest application, reboot the computer and try Open/Close again. If still not working, the USB Communication Control or digital signal processor on the Main PCBA is likely not working. Fail the Main PCBA board and repair/replace it.
		Error Code (if any): _____			
	√				
	___	Close Falcon Test application. **Note:** that Falcon Test application MUST be closed between testing different Falcons.			

14. Undo Connections.

Instructions:

- Unplug USB 2.0 Cable from Falcon device.
- Unplug Falcon Power Cord from Falcon device.

Procedures:

		Undo Connections.			
	√				
	___	Unplugged USB 2.0 cable from Falcon			
	___	Unplugged Falcon Power Cord from Falcon			

Done … move onto next unit.